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JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

MINING AND MILLING METHODS AT THE BIG JIM MINE, OATMAN, ARIZ.

BY

C. H. JOHNSON

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MINING AND MILLING METHODS AT THE BIG JIM MINE, OATMAN, ARIZ.[1]

By C. H. Johnson[2]

INTRODUCTION

The Big Jim mine of the United Eastern Mining Co. is at Oatman, Mohave County, Ariz. Catman is in the foothills on the western side of the Black Mountains, at an elevation of about 3,000 feet. It is on a paved highway about 30 miles west of Kingman, the principal distributing center for mining supplies in the district, and 25 miles from Topock, on the Colorado River. Both latter towns are stations on the Santa Fe Railroad; Oatman has no rail connection.

Mining conditions are typical of western Arizona; water is scarce, no mine timber is available locally, and the winters are mild and the summers hot. The supply of skilled labor is usually adequate, but in 1933-34 it was not more than sufficient for the restricted operations. Wages have been $4.00 to $4.50 for miners. Electric power was supplied from Kingman and cost about 2.6 cents per kilowatt-hour.

The Big Jim claim was located in 1908, but no serious work was done until about 1915 when a crosscut on the 400 level entered the Big Jim vein.[3] In 1917 the ground was purchased by the United Eastern Mining Co. In 1922 an aerial tramway was completed from the Big Jim shaft to the United Eastern mill, a distance of about 5,000 feet. From 1921 to 1924 when the United Eastern Mining Co. ceased operations, the Big Jim produced about 220,000 tons of ore with an average value per ton of about $17.25.[4]

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6824."

2/ Assistant mining engineer, U. S. Bureau of Mines Southwest Experiment Station, Tucson, Ariz.

3/ Ransome, F. L., Geology of the Oatman Gold District, Arizona: U. S. Geol. Survey Bull. 743, 1923, 58 pp.
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4/ Moore, R. W., Mining Methods and Records at the United Eastern Mine: Trans. Am. Inst. Min. and Met. Eng., vol. 76, 1928, p. 71

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In 1932 Rae L. Johnston and Ray S. Witcher leased the Big Jim ground, having decided that certain blocks of ore, too low in grade to extract under the conditions and costs prevailing in former years, could now be mined profitably.

Johnston kindly gave permission for publication of this paper and supplied most of the data. The writer is likewise indebted to B. M. Reynolds, mill superintendent, for information regarding operations at the mill.

MINING

General

The Big Jim orebody was described by Moore[5/] as a fissure vein in andesite, ranging from a solid quartz-calcite filling to a series of parallel stringers separated by andesite and of the following maximum dimensions: Height, 450 feet; length, 850 feet; thickness, 35 feet. The vein dipped 70° to 75°.

A three-compartment vertical shaft on the hanging-wall side of the vein was about 730 feet deep; the orebody was developed by five levels, the first level being above the top of the ore (which did not outcrop) and the seventh and lowest level being below the bottom of the commercial ore.

Shaft Repair

The main shaft had two cage compartments 5 feet long and 4 1/2 feet wide and a manway 4 feet long and 4 1/2 feet wide. The end and wall plates were 8- by 8-inch and the dividers 6- by 8-inch timber. The present operators found the shaft badly crushed by a cave extending from about 65 to 200 feet below the collar. At the latter point two faults converged, one dipping steeply toward the end and the other toward the side of the shaft. Some of the timbers had yielded, and subsidence had taken place along some fault planes which were well-lubricated by gouge and surface waters. The whole block had dropped about 16 feet; an opening of this height that extended 25 or 30 feet from the shaft, with a more or less flat back, was formed at the top of the block. At first an attempt was made to straighten and repair the shaft through the caved mass by using jacket sets and supporting the back of the open space by stulls resting on the broken material. It was impossible, however, to support the pressure that developed; hanger rods pulled large washers through the wall plates, and auxiliary supporting cables extending from the collar to the caved section were snapped. It was then decided to remove the caved material and to support the open ground by careful timbering. First, long stringers placed like bearer sets across the shaft were hung by cables from the surface and blocked down under the brow of the cave to support it and prevent any new falls of rock. Then it became necessary to timber with short stulls one of the fault zones whose crushed filling and gouge had slipped down into the cave; this open space was 30 or 40 feet high and 5

5/ Work cited: pp. 56-57.

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to 20 feet wide. This done and the back well-trimmed and at least partly supported by timber, mucking was started. Crews of 4 men underground and 2 men on top, working for the most part 2, but at the last 3, shifts per day, mucked and hoisted 4,500 to 5,000 tons of broken, crushed, and caved rock in a 1-ton sinking bucket and installed 21 new shaft sets and 8 jacket sets. The latter were at the bottom of the cave, where they could be blocked to solid ground. There has been no further caving; the whole former danger zone is open, though closely and intricately stulled and blocked, and can be inspected and watched. In future surface water cannot accumulate and lead to weakening or slipping of the fractured block of ground. This is an instance of the unforeseen and unpredictable expenses that may attend the simplest mining undertakings.

The work was begun September 1 and finished December 15. Shaft-men were paid $5 and $6 per shift; about $1,000 worth of timber, in the form of shaft sets and stulls, was used; and the cost of distillate for the hoist was $400 to $500 monthly. The entire job cost between $9,000 and $10,000.

Surface Plant

After the shaft was repaired preparations were made to mine. The surface plant of the Big Jim was in fair order, and little work or expenses was incurred in putting it in condition for operation. A small, wooden ore bin was purchased and moved intact from a neighboring mine to load the ore into trucks. The compressor equipment comprised two Imperial type 10 (Ingersoll-Rand) machines, one 19 by 12 by 16 and the other 17 by 10 by 14, or 1,100 and 600 cubic feet in capacity, respectively. The smaller one, more suitable for the work contemplated, lacked a motor, and a 75-hp. Allis-Chalmers motor was brought from the United Eastern mill and installed. In place of the large double-drum hoist used in former production a Fairbanks-Morse, single-drum, 60-hp., distillate-burning hoist was used, capable of raising a 1-ton car on the cage 230 feet per minute. It consumed about 25 gallons of distillate per shift, costing 14 cents per gallon.

The blacksmith shop contained a coal-burning forge, a Sullivan drill sharpener, and the usual grinding wheel, drill press, anvil, and tools.

Underground Development

The chief underground preparation for mining was to extend a track on the 500 level through an old, empty shrinkage stope by setting stulls from wall to wall until a block of low-grade ore next to the boundary line of the property was reached. The vein here was 3 1/2 to 6 feet wide and had strong walls. The block of ore was mined from the 500 to the 300 level by the open-stope method; stulls were used to hold working platforms. This form of stoping made possible a prompt and economical supply of ore to the mill without preliminary development and without tying up any of the ore as broken reserve in shrinkage.

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Later an extension of the orebody on the 600 level was developed and mined by underhand stoping. A raise was first put up to the level above and benching begun. As stoping progressed downward, a second and then a third raise are started at intervals of about 50 feet, so that by the time benching reached the 600 level at one raise the next raise had made connection to the level above.

Raises were driven 3 1/2 to 5 feet wide, according to the thickness of the ore, and 12 feet long in the vein. The length of the raise (12 feet) not only produced a fair tonnage of mill ore but also made possible the most effective pointing of the cut holes. The mixture of quartz and calcite in the vein made a "tough" but readily drilled ground which was exceedingly hard to break; the average length of a raise round was only 3 1/2 feet. The round comprised 28 to 30 holes with a center V-cut; it was drilled with stopers by two miners. The cut holes were loaded with 5 sticks each of 40-percent-strength gelatin dynamite and the other holes with 4 sticks; they were detonated with white, cotton-countered fuse and no. 8 caps. The joints between fuse and caps were painted with Celocap. Stemming was used in all holes, but only after a determined effort on the part of the mine superintendent to establish the practice; it was made of mill tailings rolled in thin paper and packed in powder boxes. The cartridges were dampened slightly before using.

When two raises were running, the miners drilled and blasted 1 day in one, and the timberman set stulls and placed staging in the other. Because of the delay involved and the need to continue a regular mill supply, chutes were not installed as promptly as usual; instead, the ore was allowed to fall into the drift and was shoveled off shoveling sheets into mine cars.

Wire-rope ladders were found convenient in the raises. They were made by the mine blacksmith of 1/2-inch wire rope and old 1/2-inch round iron; the latter was cut to proper lengths, the ends were heated and bent into the shape of a hook, then they were placed over the rope at the proper intervals and hammered fast. These ladders could readily be hung over two short pieces of steel set in holes drilled in the footwall; they withstood the wear and tear of blasting with little damage. The stulls used were salvaged from old stopes; the only expense was the labor cost of getting them out.

Approximately 1.4 man-shifts (underground), 21 pounds of powder, 75 feet of fuse, and 10 caps were expended per foot of raise. The total of these items was about $10; to this must be added compressed air, steel, supervision, and a proportion of hoisting and general underground and surface expense. Segregated costs of three such raises, based on a total advance of 85 feet in April 1933, are shown in table 1.

Underhand Stoping

The conditions in the 600-level orebody were satisfactory for underhand stoping. No timbering was necessary, and relatively high tonnage was broken per man-shift. Stopes were started at the top of a raise by drilling down holes with jackhammers. A series of benches was then carried down to the 600

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level. An essential precaution was to maintain a rill steep enough so that most of the ore would fall into the raise without shoveling; the natural tendency of the miners was to drill and blast the higher, more accessible benches first, thus burying the lower steps and flattening the slope so that the muck would not run by gravity. One miner in an underhand stope, drilling 15 to 20 holes per round each shift, broke 20 to 25 tons of ore.

Mine Costs

The following table gives the mine crew in April 1933.

Number	Classification	Wages per day
1	Foreman miner	$6.00
5	Miners	4.50
1	Timberman	4.50
3	Carmen	4.00
1	Hoist engineer	5.00
1	Blacksmith	5.00
1	Cage tender, topman	4.00

Only one shift (day) was worked. Thus 50 tons per day was mined by 10 men underground and 3 on the surface, excluding superintendence; that is, 5 tons was produced per man-shift underground, or about 3.7 tons for the entire force. Compensation insurance cost $7.25 per $100 of mine pay roll.

Some of the principal items of operating cost other than labor were as follows:

	Cost	
	Per day	Per ton
Electric power, 300 kw.-hr. per shift at $0.0267	$8.00	$0.16
Distillate for hoist, 25 gal. per shift at $0.14	3.50	.07
Explosives:		
Dynamite, 2 1/2 boxes (50 pounds) 40-percent Hercules gelatin per shift at $7.25 per box	18.15	.36
Caps, 50 per shift at $0.025 for no. 8 or $0.016 for no. 6	1.00	.02
Fuse, about 300 feet per shift at $0.008 per foot	2.40	.05

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To this must be added numerous items of supplies, such as track, pipe, oil, grease, steel, tools, coke, drill repairs, and water (which was purchased from a company pumping in a nearby shaft). Timber was not yet an item in mining costs, although it would be shortly. That purchased for shaft repair cost $40 per 1,000 board-feet, including an $8 to $9 trucking charge from Kingman.

The above cost items were determined readily from an unusually good set of records that was kept at this mine compared to ones usually kept at properties of its size. Labor, explosives, and cars trammed were entered on three daily sheets which listed all the working places. A large monthly distribution sheet was carried for each working place and for each account, such as "Hoisting", "Sharpening", etc. The data from the daily sheets were transferred to the monthly sheets, and from the latter a monthly resume was prepared, such as that shown in table 1. No warehouse account was carried; supplies consumed were entered directly from the invoices to the monthly distribution sheets.

To the costs in the following statement for April 1933 (table 1), trucking to the mill must be added. The ore was hauled by a contractor who used a single 7-ton, dump-body truck. The distance to the mill was about 1 mile, over a good, but winding, dirt road with only one short, steep grade. The ore was loaded from a chute into the truck and dumped directly into the coarse-ore bin at the mill. The contract price, including truck, labor (one driver), and all supplies, was 30 cents per ton.

MILLING

General

The mill which was rented from a neighboring company, was an all-slime cyanide plant built in 1923 by the Telluride Mining, Milling, & Development Co. at a cost said to be approximately $108,000. Its rated capacity was 50 tons per 24 hours. It was operated in 1924 and 1925, since when it had been idle. However, little expense was required to put it in operating condition. No changes or additions were made in the flow sheet or in the equipment.

The flow sheet (fig. 1) comprised coarse crushing, fine grinding (one stage of each), a stage of thickening from which the pregnant solution was derived, three stages of agitation, then five stages of thickening which produced a finished tailing. The pregnant solution was clarified, then treated by the Merrill-Crowe precipitation process. The capacity of the plant as then operated was 45 to 50 tons per day; the maximum in any day had been about 60 tons.

The ore treated contained no sulphides. Except for silver, which occurred in a ratio of 1 part to 2 parts of gold, no valuable metal other than gold was present. The ore was hard and "tough"; it consisted of roughly equal proportions of quartz and calcite, with small amounts of andesite wall rock. The gold was in the quartz and was so finely disseminated that an unusually fine degree of grinding was necessary to liberate it sufficiently for cyanidation. The presence of considerable clayey material in some of the ore, added to the tendency of the calcite to form slimes, made the pulp difficult to settle; settling area was the limiting factor in the capacity of this mill.

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TABLE 1. - Mining costs, Johnston and Witcher lease on Big Jim mine, April 1933
(1,457 tons mined)

Working place	Tons	Breaking		Tramming		Hoisting		Timbering		General underground	
		Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Breaking ore:											
501 R (overhand stope)	196	$393.91	$2.009	$32.00	$0.163	$54.31	$0.277	$16.14	$0.082	$72.52	$0.370
503 R (overhand stope)	192	102.16	.532	38.00	.198	53.13	.277	8.46	.044	37.98	.198
435 U (underhand stope)	138	125.08	.906	38.00	.275	38.28	.277	6.16	.045	27.65	.200
6 A (underhand stope)	270	324.14	1.200	50.00	.185	71.83	.266	31.01	.115	48.35	.179
506 U (underhand stope)	406	281.98	.694	62.00	.153	112.19	.276	17.46	.043	37.98	.093
Ore dump1/	96	106.16	1.106	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,298	1,333.42	1.027	220.00	.169	329.74	.255	79.23	.061	224.48	.173
Development:											
607 R	65	207.73	3.196	6.00	.092	17.80	.274	14.38	.221	24.17	.372
601 R	105	462.86	4.408	40.00	.381	29.08	.276	16.14	.154	72.52	.691
606 R	85	213.77	2.515	20.00	.235	23.44	.275	5.38	.063	24.17	.284
Total	255	884.36	3.468	66.00	.259	70.32	.275	35.90	.141	120.86	.473
Total	1,457	2,217.79	1.522	286.00	.196	400.06	.275	115.13	.079	345.34	.237
Development costs above shown separately and computed by cost per foot	Feet	Total	Per foot	Total	Per foot	Total	Per foot	Total	Per foot	Total	Per foot
607 R	20	207.73	10.386	6.00	.300	17.80	.892	14.38	.719	24.17	1.208
601 R	45	462.86	10.285	40.00	.888	29.08	.646	16.14	.360	72.52	1.611
	20	213.77	10.688	20.00	1.000	23.44	1.173	5.38	.269	24.17	1.208
Total	85	884.36	10.404	66.00	.776	70.32	.827	35.90	.422	120.86	1.423

1/ Payment to lessees working shaft dump on "split-check" basis.

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I.C. 6824 TABLE 1. - Mining costs, Johnston and Witcher lease on Big Jim mine, April 1933--Continued
(1,457 tons mined)

Working place	Tons	Steel sharpening		Compressed air		Drill steel, hose, oil		Total cost of mining	
		Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Breaking ore:									
501 R (overhand stope)	196	$44.64	$0.228	$43.40	$0.221	$14.18	$0.072	$671.10	$3.424
503 R (overhand stope)	192	23.38	.122	21.70	.113	7.43	.039	292.24	1.522
435 U (underhand stope)	138	17.00	.123	14.46	.105	5.40	.039	272.03	1.971
6 A (underhand stope)	270	29.76	.110	28.93	.107	9.47	.035	593.49	2.198
506 U (underhand stope)	406	23.38	.057	21.70	.053	7.43	.018	564.12	1.389
Ore dump[1/]	96	.....	.....	.....	.....	.....	.....	106.16	1.106
Total	1,298	138.16	.106	130.19	.100	43.91	.034	2,499.14	1.925
Development:									
607 R	65	14.89	.229	14.46	.222	4.73	.073	304.16	4.679
601 R	105	44.64	.425	43.40	.413	14.18	.135	722.82	6.884
606 R	85	14.89	.175	14.46	.170	4.73	.056	320.84	3.757
Total	255	74.42	.292	72.32	.284	23.64	.093	1,347.82	5.285
Total	1,457	212.58	.146	202.51	.138	67.55	.047	3,846.96	2.640
Development costs above shown separately and computed by cost per foot	Feet	Total	Per foot	Total	Per foot	Total	Per foot	Total	Per foot
607 R	20	14.89	.744	14.46	.723	4.73	.236	304.16	15.208
601 R	45	44.64	.992	43.40	.964	14.18	.315	722.82	16.061
606 R	20	14.89	.745	14.46	.723	4.73	.236	320.84	16.042
Total	85	74.42	.876	72.32	.851	23.64	.278	1,347.82	15.857

1/ Payment to lessees working shaft dump on "split-check" basis.

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Crushing and Grinding

The ore was dumped from the trucks over a steeply slanting grizzly formed of flat steel bars set on edge with 1-inch spacing. The fine material fell into a separate section of the coarse-ore bin. The oversize ran into a coarse-ore bin which had a capacity of 30 to 35 tons; it was built of wood and had a sloping bottom. From this bin the ore was drawn by gravity through a feed gate to the coarse crusher. The crusher product passed directly onto an inclined conveyor belt, 12 inches wide and about 200 feet long, which discharged into the fine-ore bin. The grizzly undersize was fed through a separate gate onto the lower end of the same belt and conveyed to the fine-ore bin when the crusher was not running. The crusher was belt driven by a 50-hp. electric motor. It was operated 4 to 6 hours each day shift, crushing at a rate of 11 to 12 tons per hour. The conveyor belt passed through a Merrick weightometer; the tonnage recorded by this machine was found to check very closely the tonnage estimated according to number of 1-ton mine cars trammed to the mine surface bin; the monthly discrepancy was usually less than 1 percent.

The conveyor discharged into the center of the square, wooden, flat-bottomed, fine-ore bin, which had a maximum capacity of 80 tons. A hand-operated sample cutter was installed at the head of the conveyor belt. From a center discharge gate in the bottom of the fine-ore bin an apron feeder delivered the ore to the ball mill.

The ball mill was a 6- by 4 1/2-foot Marcy mill with Williamson "mechanite" liners that were changed to standard Marcy liners about 1933. It was driven at 18 r.p.m. by a 75-hp. motor and operated in closed circuit with a Dorr duplex classifier. The classifier discharge was 82 to 85 percent minus 200-mesh; it was later changed to 80 to 82 percent. Ball consumption ranged from 2.5 to 4.5 pounds of chrome-steel balls per ton or ore; the mill run had been too short to determine liner consumption. The ball mill operated from 78 to 80 percent of the total time; grinding capacity was 2.5 tons per hour of operating time.

Grinding was done in cyanide solution, which was drawn from the main-mill storage tank at the rate of about 330 tons per 24 hours. A portion of this was added in the feed launder at the head of the mill; the balance was added at the lower end of the classifier. About 50 percent of the value recovered from the ore was dissolved in the mill.

Cyanide Section

The classifier overflow, having a dilution of 6 to 1 (or carrying 15 percent solids), flowed by gravity to the no. 1 thickener in the cyanide plant. This was a wood-stave tank 24 feet in diameter and 8 feet deep. It was equipped, as were all the thickeners and agitators, with a Dorr mechanism which was belt-driven through a long countershaft by a single 25-hp. motor. The thickener overflow passed by gravity to the precipitation section of the plant. The thickened discharge, containing about 40 percent solids, was raised by a diaphragm pump to the first of a series of three agitating tanks.

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The tank of no. 1 agitator was 19 feet in diameter and 14 feet deep; nos. 2 and 3 agitators were 13 feet in diameter and 14 feet deep. The agitators were set at such relative elevations that the pulp flowed from one tank to the next by gravity. Air for the agitator air lifts, as well as for periodical drying of precipitate in the filter press, was furnished by a 7 1/2- by 6-inch compressor at a pressure of 30 pounds per square inch. The compressor was driven by a 10-hp. motor.

About 95 percent of the gold recovered was taken into solution by the time the pulp left no. 3 agitator. From there it went to no. 2 thickener, whence it was pumped in turn to thickeners 3, 4, 5, and 6. These thickeners were all 15 feet in diameter and 10 feet deep. They were set at such heights that the clear overflow from each ran by gravity to the next lower numbered tank. The thickened-pulp discharges contained about 50 percent solids. Fresh water was added to no. 6 thickener in the amount of 50 tons daily; the barren solution from the precipitation section, 180 tons daily, was added to the feed launder of no. 4 thickener. This solution contained about 2.2 pounds of sodium cyanide and 2.0 pounds of lime per ton, also a trace of gold. The overflow from no. 2 thickener, 330 tons per day, was pumped to the mill storage tanks. The thickened slime from no. 6 thickener flowed to the tailings dump. No solution was reclaimed from the tailings; they were allowed to run down the draw below the mill; within a short distance the water sank into the ground.

The overflow from no. 1 thickener ran by gravity into a Butters clarifying filter having a tank 11 feet in diameter and 5 1/2 feet deep; thence it was pumped into the clear gold-solution tank 11 feet in diameter and 6 feet deep. From this tank it passed through the standard Merrill-Crowe, vacuum-treatment, zinc-dust precipitation process. Zinc dust and lead acetate were added to an emulsifier ahead of the triplex circulating pump by an automatic feeder. The Merrill precipitate press was installed in a room adjacent to the grinding section of the mill about 200 feet from the pump.

Melting Precipitate

Usually the precipitate press was cleaned about twice monthly, after first blowing air through it for 3 to 4 hours to dry the precipitate. The precipitate was fluxed about as follows: Precipitate, 100 pounds; borax, 20 pounds; soda, 10 to 12 pounds; silica (broken glass), 6 pounds. This charge, together with some slag from the previous melt, was melted in an oil-fired tilting furnace. The fusion usually required 8 to 9 hours, including the time needed to put in and melt down the charge; the furnace consumed 25 or 30 gallons of fuel oil in this time. Compressed air for the oil burner was obtained from the compressor at the Telluride mine, where development work was in progress. The no. 150 Dixon graphite crucibles used had a life of about 40 hours, or 4 or 5 fusions. The entire charge was poured off into a cone-shaped mold; after a few minutes the slag was tapped off through a hole 2 or 3 inches above the top of the gold button and granulated by being run into water. At first this material was accumulated, periodically ground in a small mill, and concentrated on a table, the concentrates being added to a later precipitate melt. Afterward the low-grade slag was returned to the ball mill, as it was found to contain practically no shot gold. The richer slag from just above the top of the button contained most of the shot gold; it was melted with the succeeding charge.

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The gold-silver button was cleaned and shipped to the mint without remelting; a sample was taken first by boring several small holes in it. The average fineness was 640 parts per 1,000 of gold, and 300 parts of silver, and 60 parts of base metal and impurities.

Metallurgical Results and Costs

The recovery was 97 to 98 percent. Cyanide consumption was 0.75 to 1.00 pound of sodium cyanide per ton of ore, and lime consumption was 3 3/4 to 4 pounds per ton. Zinc dust was added at the rate of 8 pounds per 24 hours, or 0.7 ounce per ton of solution, and lead acetate at the rate of 1 ounce per ton of ore.

The mill pay roll included 9 men: 1 superintendent whose time was charged to assaying and refining; 1 crusher man on day shift only; 1 man whose time was divided between assaying, refining, and general service; and 2 shift men, or operators, on each of three 8-hour shifts. Experienced men were paid $4.50 and ordinary labor $4.00.

Power cost $0.0267 per kilowatt-hour (May 1933). The total installed electric power in the mill was 200 hp., divided as follows:

Motor	Hp.
Crusher	50
Ball mill	75
Main conveyor	10
Apron feeder	5
Compressor	10
Cyanide plant	25
Pumps	25

However, the crusher operated only about 5 hours and only on day shift; the ball-mill motor was said to be operating at only about 70 percent full load. Consequently, the average total mill load was about 90 hp., and power consumption was about 30 kw.-hr. per ton.

Cyanide (Aero Brand sodium cyanide) cost $160 per ton (April 1933); lime cost $19 per ton, of which $5.50 was trucking cost from Kingman to Oatman; zinc cost $8 per 100 pounds; and the monthly water bill, for a daily consumption of about 50 tons, was about $100, or about 30 cents per 1,000 gallons.

The costs shown in the following regular monthly statement (table 2) are representative.

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TABLE 2. — Milling cost, Johnston and Witcher lease on Big Jim mine, July 1933

(1,635 tons milled)

	Labor		Electric power		Water		Lime		Miscellaneous chemicals		Cyanide		Zinc	
	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Assaying 1/ ..	$283.00	$0.173	$10.15	$0.006	.....	.....	.....	.....	$20.11	$0.012	.....	.....	.....	.....
Crushing	140.13	.086	30.43	.018	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Grinding	393.88	.241	507.26	.310	.....	.....	.....	.....	29.10	.018	.....	.....	.....	.....
Cyaniding	425.19	.260	456.54	.279	$78.61	$0.048	$116.51	$0.071	4.91	.003	$172.62	$0.106	$32.00	$0.020
Repair and replacement..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Refining and marketing ...	31.50	.019	10.14	.006	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rental of mill	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Total	1,273.70	.779	1,014.52	.620	78.61	.048	116.51	.071	54.12	.033	172.62	.106	32.00	.020

	Replacement and repair parts		Balls		Fuel oil and lubricants		Insurance and shipping		Mill rental and miscellaneous		Total cost of milling	
	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton	Total	Per ton
Assaying 1/ ..	.....	.....	.....	.....	$9.99	$0.006	.....	.....	.....	.....	$323.25	$0.197
Crushing	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	170.56	.104
Grinding	$58.25	$0.036	$130.77	$0.080	2.02	.001	.....	.....	.....	.....	1,121.28	.686
Cyaniding	19.92	.012	.....	.....	4.50	.003	.....	.....	.....	.....	1,310.80	.802
Repair and replacement..	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Refining and marketing ...	.....	.....	.....	.....	10.05	.006	$8.64	$0.005	.....	.....	60.33	.036
Rental of mill	.....	.....	.....	.....	.....	.....	.....	.....	$1,000.00	$0.612	1,000.00	.612
Total	78.17	.048	130.77	.080	26.56	.016	8.64	.005	1,000.00	.612	3,986.22	2.437

1/ Cost of assaying includes cost of superintendence.

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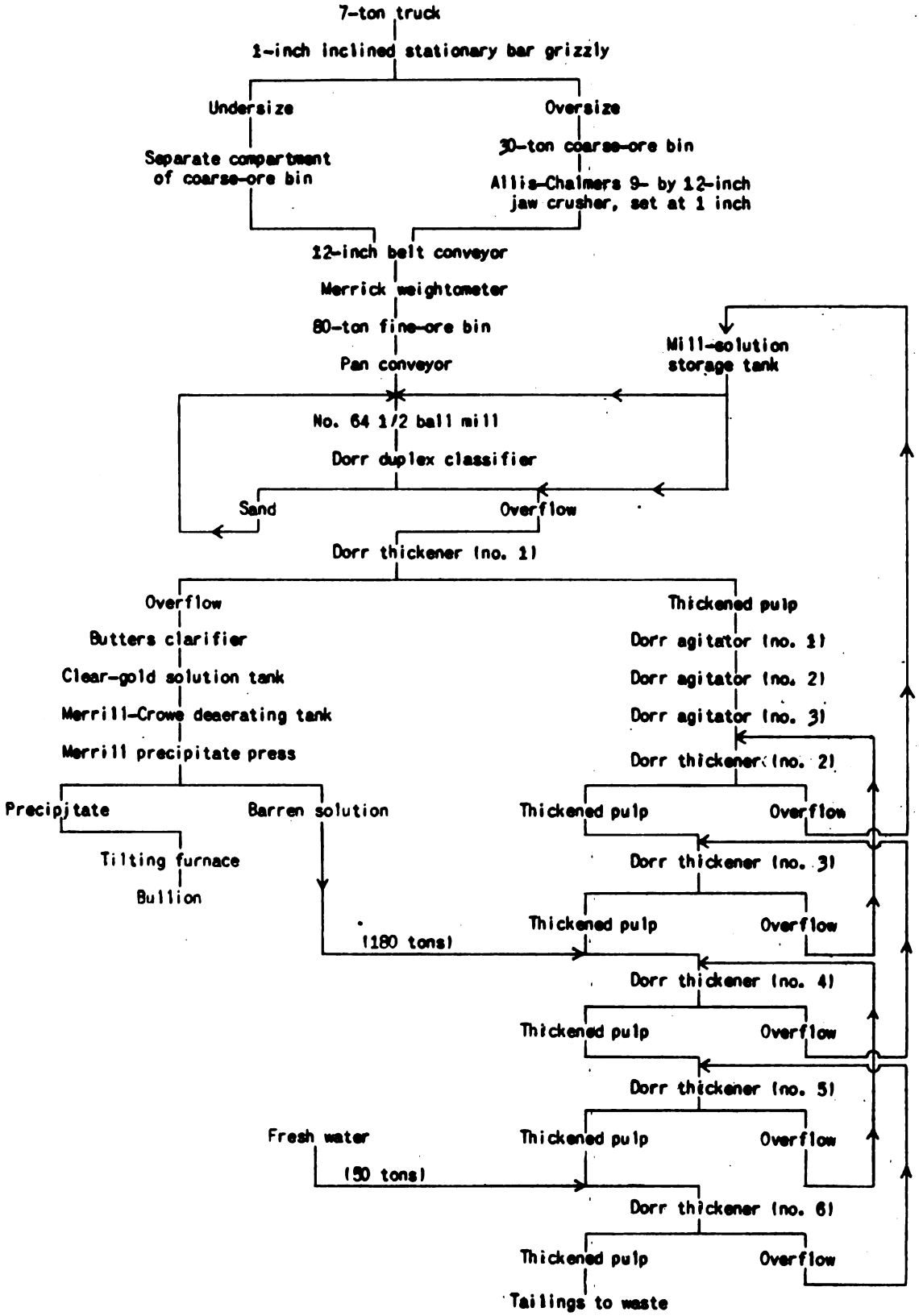

Figure 1.- Flow sheet of Big Jim (Telluride) mill.

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